



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : B23K 37/04, 20/12		A1	(11) International Publication Number: WO 99/34951
			(43) International Publication Date: 15 July 1999 (15.07.99)

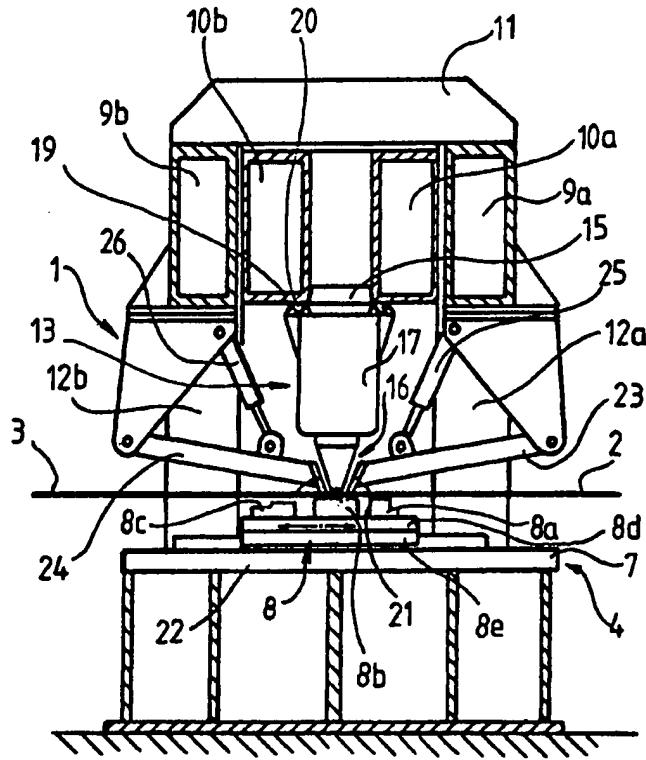
(21) International Application Number: PCT/SE98/02390	(81) Designated States: AL, AM, AT, AT (Utility model), AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, EE (Utility model), ES, FI, FI (Utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).
(22) International Filing Date: 18 December 1998 (18.12.98)	
(30) Priority Data: 9704800-3 19 December 1997 (19.12.97) SE	
(71) Applicant (for all designated States except US): ESAB AB [SE/SE]; P.O. Box 8004, S-402 77 Göteborg (SE).	
(72) Inventor; and	
(75) Inventor/Applicant (for US only): LARSSON, Rolf [SE/SE]; Bäverstigen 14, S-695 31 Laxå (SE).	
(74) Agent: AWAPATENT AB; P.O. Box 11394, S-404 28 Göteborg (SE).	Published <i>With international search report. In English translation (filed in Swedish).</i>

97850179

(54) Title: APPARATUS FOR FRICTION STIR WELDING

(57) Abstract

The invention concerns an apparatus for friction stir welding, comprising a welding unit (6) including a welding head (13), a worktable (4) including a backing unit (8) to support the workpieces (2, 3) to be welded together along their joint line, and clamping means (21, 22) to clamp the workpieces to the worktable in a direction towards one another during the welding operation. The backing unit consists of at least two backing parts (8a, 8b, 8c; 28a, 28b) or of at least one backing part (8a, 8b, 8c; 28a, 28b) and one additional welding head (30; 32), said backing parts being freely exchangeable, one for the other, before each welding operation as is also each backing part for an additional welding head, and vice versa.



When the milling tool has traversed the entire joint and the individual milling operation thus is completed, the pressure cylinders 25 and 26 are activated, allowing the workpieces to be released from the clamping means 21 and 22, if the workpieces, following the milling operation, are to be welded together with the use of the friction stir welding technique. By activation of said pressure cylinders, the workpieces 2 and 3 may thereafter be fixed in the position shown in Fig 4a. It is likewise possible to fasten the second workpiece already from the start in such a manner that it may be secured in the same position during both the milling and the friction stir welding operations, i.e. following the milling step only the left-hand pressure cylinder 26 need be activated for release and subsequent clamping of the left workpiece 3. The milling tool is thereafter exchanged for the friction stir welding probe, which is caused to rotate at a predetermined speed while at the same time it is being moved along the gap at a predetermined speed. As explained in the introduction hereto, the workpiece edges to be joined together will be plasticized by the frictional heat generated in this process, while at the same time they will be pressed against the worktable. After solidification, a homogeneous welded joint is formed, possessing high-strength qualities. When the friction stir welding probe 16 has traversed the entire joint and the individual welding operation thus is completed, the pressure cylinders 25 and 26 are again activated, causing deactivation of the clamping means 21 and 22, and consequently release of the formed product.

If the desired product is to comprise more than two workpieces, it may be necessary to perform milling in between each welding operation in order to produce a high-quality end product.

It should be appreciated that the invention is not limited to the above embodiments but that numerous modifications are possible within the scope of the

appended claims. For example, the welding probe may be automatically instead of manually exchangeable for the milling tool with the aid of a tool switching device, not shown. Instead of the movable backing unit shown in Fig 2 5 it is of course possible to design the welding apparatus in such a manner that its welding unit, the clamping means and the workpieces are arranged to be displaced laterally relative to the backing unit. In order to further increase the capacity of the welding apparatus a 10 number of friction stir welding heads could be placed above and/or underneath the workpieces. The welding head/heads could be fitted with special mounting and transportation means in order to facilitate the shifting of the various welding heads between different welding 15 apparatuses. It is likewise possible to use a pallet or transfer carriage system to move and connect the welding heads to different welding apparatuses.

In the description above, the starting position wherein a backing unit in the form of a backing element 20 and a welding head operating vertically above said element has been used, but obviously the welding may be performed from below, against a backing unit positioned in contact with the upper face, or with vertically orientated workpieces and horizontally directed welding. 25 In a welding apparatus of Fig 5, the upper head could in this case be replaced by a backing unit and the welding be performed from underneath. It is likewise possible to arrange the welding apparatus in such a manner that a fusion welding head is used on the upper face and a 30 friction welding head on the lower one.

CLAIMS

1. An apparatus (1) for friction stir welding, comprising a welding unit (6) including a welding head (13, 14), a worktable (4) including a backing unit (8; 28; 30; 32) to support the workpieces (2, 3) to be welded together along their joint line, and clamping means (21, 22) to clamp the workpieces to the worktable in a direction towards one another during the welding operation, characterised in that the backing unit consists of at least two backing parts (8a, 8b, 8c; 28a, 28b) or of at least one backing part (8a, 8b, 8c; 28a, 28b) and one additional welding head (30; 32), said backing parts being freely exchangeable, one for the other, before each welding operation as is also each backing part for an additional welding head, and vice versa.

2. An apparatus as claimed in claim 1, characterised in that at least one of the backing parts (8a, 8b, 8c; 28a, 28b) and/or the additional welding head (30; 32) is/are displaceable in a direction perpendicular to the joint line of the workpieces (2, 3).

3. An apparatus as claimed in any one of claims 1 or 2, characterised in that the welding unit (6) and the clamping means (21, 22) are displaceable in a direction perpendicular to the direction of movement of the welding unit relative to the backing unit (8; 28; 30; 32) in order to allow displacement of the joint line of the workpieces (2, 3).

4. An apparatus as claimed in any one of the preceding claims, characterised in that at least one backing part (8b; 28a, 28b) has a plane upper face.

5. An apparatus as claimed in any one of claims 1 - 4, characterised in that at least one backing part (8a, 8b) has a stepped upper face.

6. An apparatus as claimed in any one of claims

1 - 5, characterised in that one backing part is a separate backing element (8a, 8b, 8c), such as a bottom backing.

7. An apparatus as claimed in any one of claims

5 1 - 5, characterised in that two backing parts are formed by two backing pieces (28a, 28b), such as bottom backing pieces.

8. An apparatus as claimed in claims 6 and 7,

10 characterised in that the backing unit consists of at least one separate backing element (8a, 8b, 8c) and of at least two backing pieces (28a, 28b).

9. An apparatus as claimed in claim 6, characterised in that the backing unit consists of three separate backing elements (8a, 8b, 8c).

15 10. An apparatus as claimed in claim 9, characterised in that one (8b) of the backing elements is formed with a plane upper face and in that the two other backing elements (8a, 8c) are formed with a stepped upper face, the steps of the two latter backing elements 20 being of different heights.

11. An apparatus as claimed in any one of the preceding claims, characterised by a means (33) for shifting the additional welding head (32) from a position underneath the joint line of the workpieces (2, 25 3) to a position above said line.

12. An apparatus as claimed in any one of the preceding claims, characterised in that at least one welding head (13) is arranged to alternatively serve as a milling head.

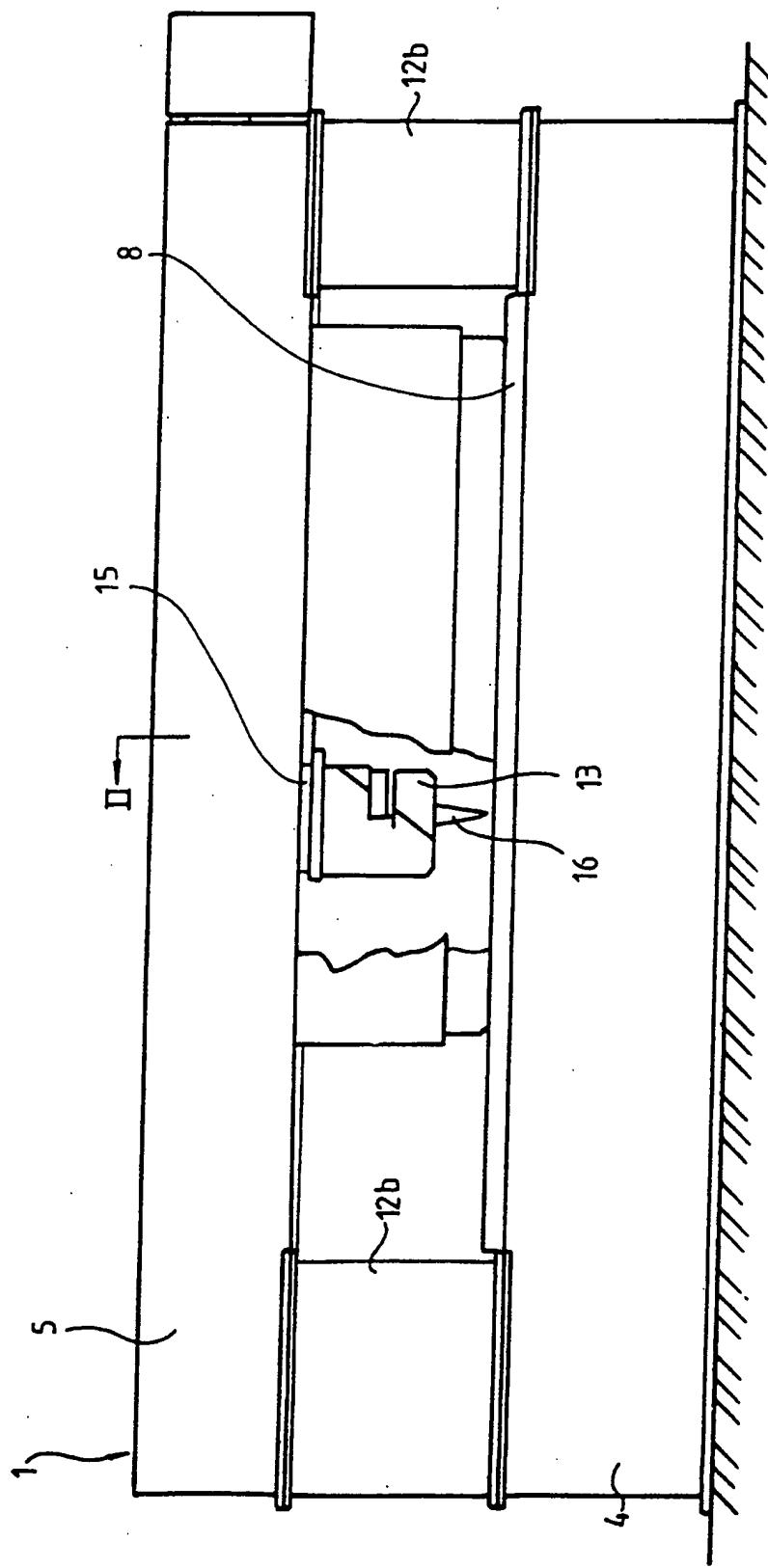


Fig. 1

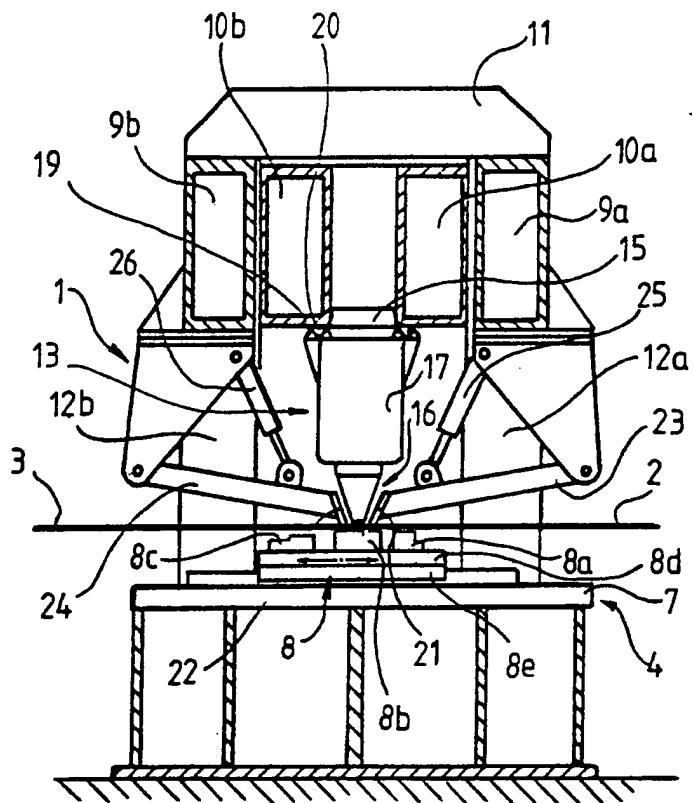


Fig. 2

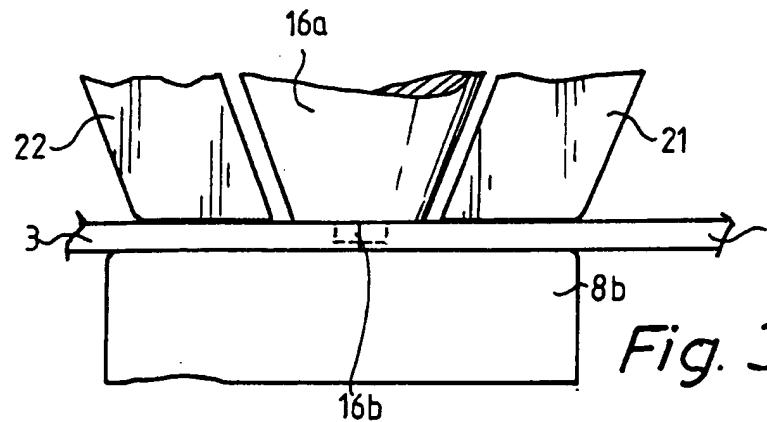


Fig. 3a

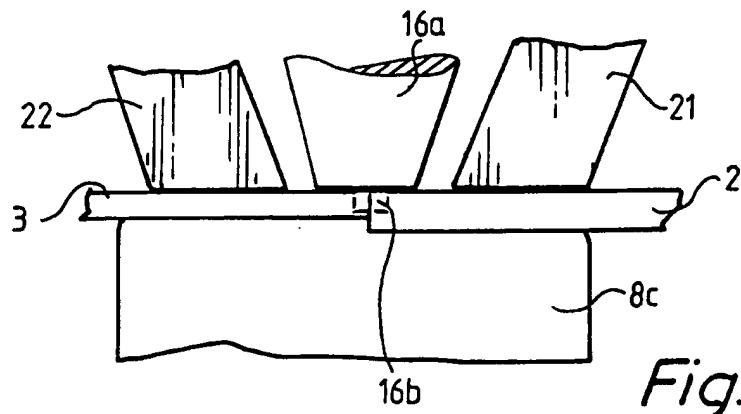


Fig. 3b

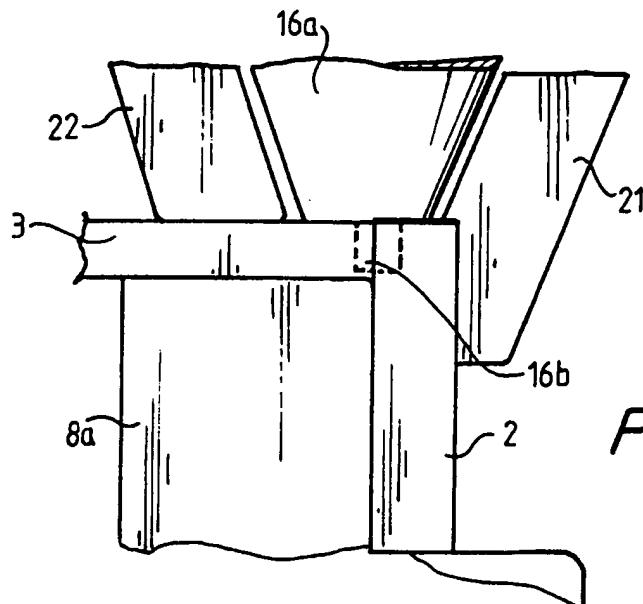
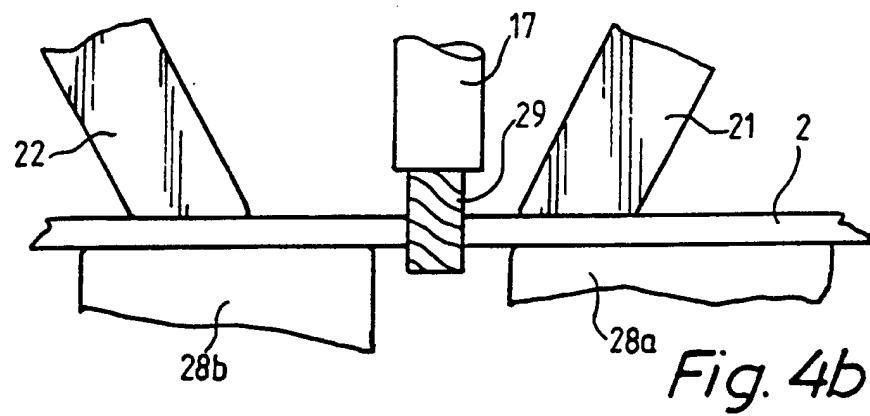
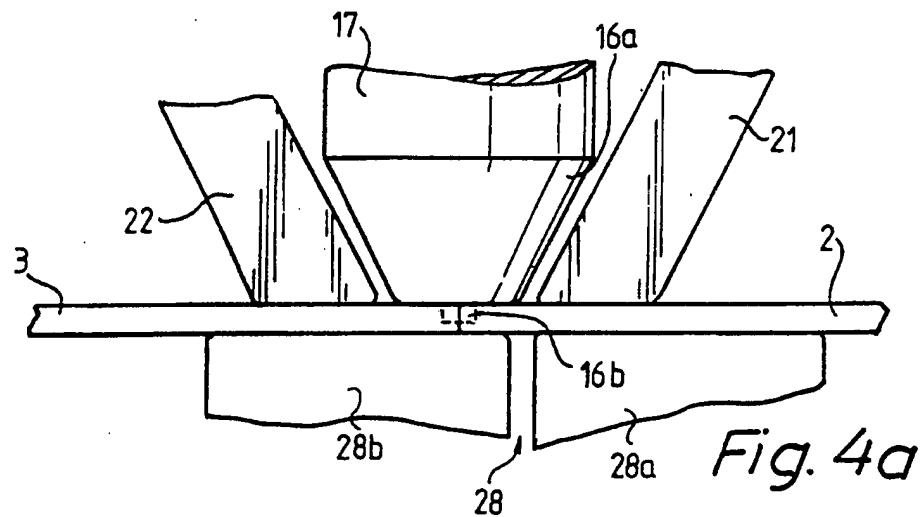


Fig. 3c



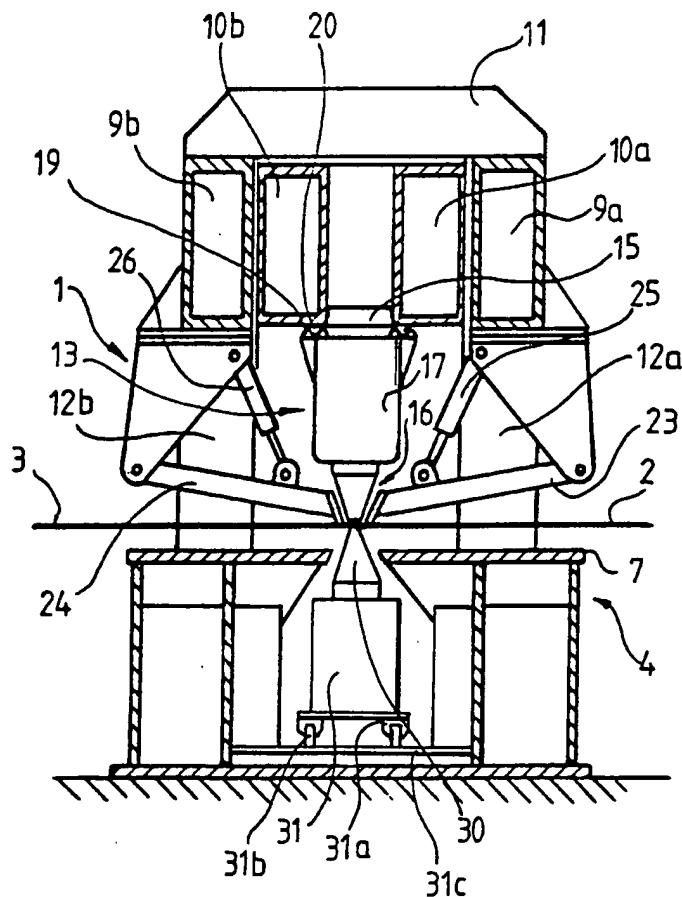


Fig. 5

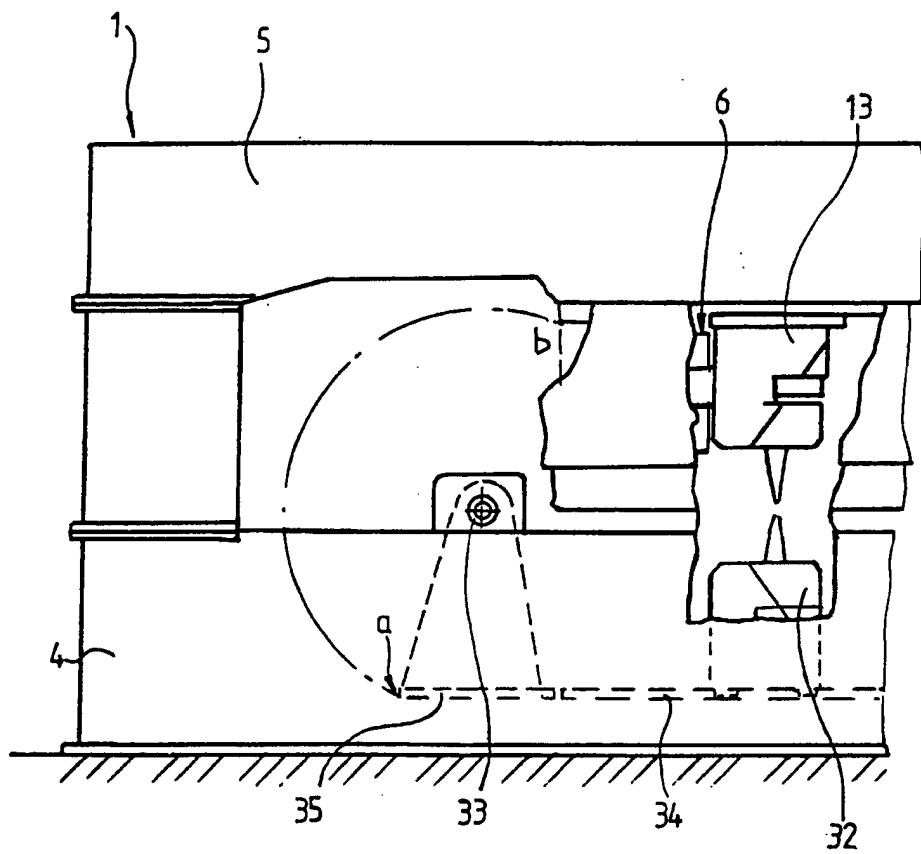


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 98/02390

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: B23K 37/04, B23K 20/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: B23K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI,EDOC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0797043 A2 (HITACHI, LTD.), 24 Sept 1997 (24.09.97), column 7, line 4 - line 24; column 8, line 13 - column 9, line 9, figures 10,14	1
Y	--	2-16
Y	DE 1116034 B (KNAPSACK-GRIESHEIM AKTIENGESELLSCHAFT), 26 October 1961 (26.10.61), column 4, line 9 - column 5, line 8, figures 1-5	2-7
Y	DE 1627555 A (MESSER GRIESHEIM GMBH), 28 January 1971 (28.01.71), page 7, line 1 - page 8, line 3, figures 6-10	8-10
	--	

 Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

Date of mailing of the international search report

8 April 1999

19-04-1999

Name and mailing address of the ISA/
Swedish Patent Office
Box 5055, S-102 42 STOCKHOLM
Facsimile No. + 46 8 666 02 86

Authorized officer

Ulf Nyström
Telephone No. + 46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No. PCT/SE 98/02390
--

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	SE 407914 B (ENTREPOSE G.T.M POUR LES TRAVAUX PETROLIERS MARITIMES E.T.P.M.SA), 23 February 1975 (23.02.75), page 7, line 9 - page 8, line 21, figures 1-16 --	11
Y	EP 0810055 A1 (THE BOEING COMPANY), 3 December 1997 (03.12.97), column 1, line 20 - line 31 -- -----	12

INTERNATIONAL SEARCH REPORT

Information on patent family members

02/03/99

International application No.

PCT/SE 98/02390

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
EP 0797043 A2	24/09/97	JP	9309164 A	02/12/97
DE 1116034 B	26/10/61	NONE		
DE 1627555 A	28/01/71	GB	1236639 A	23/06/71
		JP	49033016 B	04/09/74
		SE	340210 B	08/11/71
		US	3593907 A	20/07/71
SE 407914 B	23/02/75	BE	809815 A	16/05/74
		CA	996200 A	31/08/76
		DE	2403189 A,B,C	06/03/75
		DK	420574 A	28/04/75
		FR	2241376 A,B	21/03/75
		GB	1459123 A	22/12/76
		IE	39057 B	19/07/78
		JP	958787 C	14/06/79
		JP	50045755 A	24/04/75
		JP	53037825 B	12/10/78
		LU	69167 A	08/04/74
		NL	7401418 A	25/02/75
		SE	7404213 A	24/02/75
		US	3904845 A	09/09/75
EP 0810055 A1	03/12/97	CA	2204571 A	30/11/97
		CN	1167024 A	10/12/97
		JP	10071477 A	17/03/98
		US	5794835 A	18/08/98